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CENTRAL FORECASTING TECHNICAL NOTE NO. 13

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AVIATION FORECAST BULLETINS FROM BRACKNELL

BY

S.D.TURNER AND P.J.SMITH

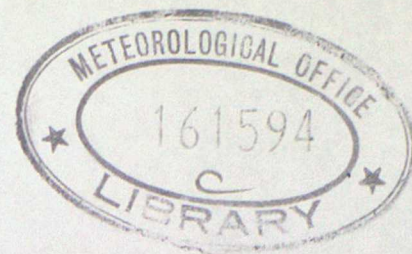
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ON THE USE OF GRIDDED BINARY CODE IN PRODUCING
AVIATION FORECAST BULLETINS FROM BRACKNELL

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AUGUST 1993

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GRIDDED BINARY CODE PRODUCTS FROM BRACKNELL

(This paper closely follows a paper from the US National Meteorological Centre 'Exchange format for weather product messages'.)

INTRODUCTION

GRIB (GRIdded Binary) code is a general purpose bit-orientated code developed by WMO as a highly efficient data exchange format used for transmitting large volumes of gridded data over high speed telecommunication lines. The data is packed into GRIB code making the bulletins more compact so decreasing the transmission time between computers. Each bulletin contains a grid point field of a single parameter at a single level as a continuous bit-stream made of a sequence of octets (1 octet = 8 bits) within a communications envelope. The octets of a GRIB message are grouped in blocks. Each block will always contain an even number of octets, this may mean zero filling at the end of a block. The Bracknell GRIB code bulletins for aviation consist of four blocks preceded by a WMO abbreviated heading:

- WMO header
- Indicator block (IB)
- Product definition block (PDB)
- Binary data block (BDB)
- End block (EB)

The WMO header is part of the telecommunications envelope which for the present is character-orientated, content dependent and contains the standard. WMO abbreviated heading. This header should not be used as the sole determiner of the message content, the Product Definition Block should be the main determiner.

In the message as transmitted on the communications lines, the WMO header is preceded by sixteen octets of 'communications header'. The communications people also add an ASCII 'carriage return, carriage return, line feed, end of transmission string', - (0D0D0A03) hex - after the End Block.

In this documentation all hexadecimal numbers are enclosed in parentheses followed by the word 'hex', decimal numbers are printed as they are and a single string of characters is represented inside single quotes. Character representation in GRIB is in standard 7-bit ASCII (or International Alphabet No.5)

DATA PACKING METHOD

Data are coded as binary integers using the minimum number of bits required for accuracy; values are given relative to an encoded reference value and are scaled by a power of two. The representation of a single value is such that:

$$Y = R + (X * 2^{**E})$$

where Y = real value
R = reference value (32 bits)
X = packed value
E = scale factor (sign bit, followed by a 15 bit integer)

The reference value R is, for our purposes always the minimum value of the data that is being represented in the code. R is a four octet single precision floating point number, with the first bit representing the sign bit, the next seven the characteristic, and the remaining 24 bits the mantissa.

THE COMMUNICATIONS HEADER

This precedes the WMO bulletin header.

Octet No.

1	SOH start of header control character (01) hex.
2-4	Two ASCII carriage returns and a line feed (0D0D0A) hex.
5-7	3 character sequence number assigned to a particular transmission block by the communications software at time of transmission.
8	blank (20) hex
9-13	5 character number assigned to the product for switching purposes at some centres. These are ignored at Bracknell.
14-16	Two ASCII carriage returns and a line feed (0D0D0A) hex.

WMO BULLETIN HEADER

The WMO abbreviated heading is used to identify the GRIB message at present, although as mentioned earlier it should not be the sole determiner of the message contents. The characteristics in the WMO bulletin header are in ASCII (or CCITT-ITA N0.5) and are defined as follows:

Octet N0.

1	The character 'H' identifies the bulletin as being in GRIB code.
2	A letter character specifies the type of parameter, see Table 1
3	A letter character specifies the gird area, see table 2
4	A letter character indicating the time difference between the reference time and valid time of the data, see Table 3
5-6	Two numeric characters specifying the level of the data, see table 4
7	blank (20) hex
8-11	Four characters identifying the originating centre. These are always 'EGRR' for Bracknell products.
12	blank (20) hex
13-14	Two numeric characters providing the reference day of the month.
15-18	Four numeric characters providing the reference hour and minute of the data in the product message.
19-21	Two ASCII carriage returns and a line feed (0D0D0A) hex.

INDICATOR BLOCK (IB)

Octet No.

1	'GRIB' (coded CCITT-ITA N0.5)
---	-------------------------------

PRODUCT DEFINITION BLOCK (PDB)

Octet No.

1-3	Length of block (in our case 24 octets)
4	Set to zero
5	Identification of centre; Bracknell is 4A (hex)
6	Model identification, see Table 5
7	Grid identification, see Table 2
8	Indicator for presence of Grid Description Block and Bit Map block (set to zero for aviation GRIB i.e. both omitted)
9	Indicator of parameter, see Table 6
10	Indicator of type of level, see Table 4 and note 1
11-12	Height, pressure etc. of the level, see Note 1
13	Year of century)
14	Month of year)
15	Day of month) Reference time of data
16	Hour of day)
17	Minute of hour)
18	Indicator of forecast time unit (set to 1; time unit hours)
19	Time range (number of forecast time units)
20-24	reserved (set to zeros)

Note (1) Octets 10,11 and 12 of the product definition block.

Octet 10		Octet 11	Octet 12
Value	Meaning		
00-99	Special codes 01 surface of earth 06 maximum wind 07 tropopause	0	0
100	Isobaric level	pressure in hPa (millibars)	
102	Mean sea level	0	0

GRID DESCRIPTION BLOCK (GDB) (OPTIONAL)

The Grid description block is optional. If it is coded then Octet 7 in the product definition block is set to 999. The GDB contains a full description of the grid.

Octet No.

1-3	Length in octets of GDB
4	Number of unused bits at end of the block
5	Reserved set to zero
6	Type of grid (00)hex = lat./long.
7-8	Number of points along a parallel (number of columns)
9-10	Number of points along a meridian (number of rows)
11-13	Latitude of first grid point
14-16	Longitude of first grid point
17	Resolution flag (normally set to (80)hex - direction increments given
18-20	Latitude of last grid point
21-23	Longitude of last grid point
24-25	Grid spacing along a parallel
26-27	Grid spacing along a meridian
28	Scanning mode (set to (00)hex for w-e, n-s, set to (40)hex for w-e s-n)
29-32	Reserved set to zero

BIT MAP BLOCK (BMB) (OPTIONAL)

This block is used to bitmap out missing data.

Octet No.

1-3	Length of block
4	Number of unused bits at end of block
5-6	Table reference; if the octets contain zero a bit map follows if the octets contain a number it refers to a pre-defined bit map
7	Bitmap. Contiguous bits with a bit to data point correspondence ordered as defined in the grid definition.

BINARY DATA BLOCK (BDB)

The BDB contains both the scaling information needed to reconstruct the original data and the packed data. The data is zero filled to an even number of octets.

Octet No.

1-3	Length in octets of BDB (even number)
4	First 4 bits set to zero, last 4 bits give number of unused bits at the end of the block.
5-6	Scale factor (e)
7-10	Reference value (r) (minimum value)
11	Number of bits into which the data is packed.
12-nnn	Binary data

END BLOCK (EB)

Octet No.

1-4	'7777' indicates end of message (coded CCITT-ITA No.5)
-----	--

COMMUNICATIONS TRAILER

The following four octets are added after the end block.

Octet No.

1-4	Carriage return, carriage return, line feed, end of transmission (0D0D0A03) hex
-----	--

APPENDIX ATablesTABLE 1TYPE PARAMETERS (Octet 2 of WMO header)

<u>Type</u>	<u>No. of bits</u>	<u>Parameter</u>	<u>Unit</u>
T	8	Temperature	degrees C
U	8	Eastward wind component	m/sec
V	8	Northward wind component	m/sec
P	12	Pressure	hPa (mb)
H	12	Height	m
R	8	Relative Humidity	%

TABLE 2GRID AREA AND LOCATION (Octet 3 of WMO header)
(Octet 7 of PDB)

<u>GRID AREA</u> <u>(WMO)</u>	<u>OCTET 7</u> <u>PDB</u>	<u>RESOLUTION</u> <u>(LON X LAT)</u>	<u>AREA COVERAGE</u>	<u>GRID</u> <u>COLS</u>	<u>SHAPE</u> <u>ROWS</u>	<u>GRID</u> <u>POINTS</u>
A	21	5.0 X 2.5	0-180E,0-90N	37	36+POLE	1333
B	22	5.0 X 2.5	180W-0,0-90N	37	36+POLE	1333
C	23	5.0 X 2.5	0-180E,90S-0	37	36+POLE	1333
D	24	5.0 X 2.5	180W-0,90S-0	37	36+POLE	1333

Notes on contents of table 2

- 1) The grid points are laid out in a linear array such that the longitude index is the most rapidly varying. The first point in the message is at the western most meridian and the southern circle of latitude.
- 2) Data for the pole points are given only once in each of the bulletins A,B,C,D. Wind components at the poles are given by the formulae:

$$u = -\text{speed} \times \sin(\text{dd})$$

$$v = -\text{speed} \times \cos(\text{dd})$$

Where dd is the direction as reported according to the specification of wind direction at the poles (refer to WMO Manual on Codes publication No. 306 Vol 1 code table 878) At the North Pole you face into the wind and report the value of the west longitude meridian along which the wind is coming at you; at the South Pole you do likewise but report the east longitude meridian value.

TABLE 3FORECAST HOUR DESIGNATOR (Octet 4 of WMO header)

When 'H' is first letter of abbreviated heading

<u>Designator</u>	<u>Forecast Hour</u>
A	00 hour forecast
B	06 " "
C	12 " "
D	18 " "
E	24 " "
F	30 " "
G	36 " "

TABLE 4 LEVEL DESIGNATION (Octet 5 and 6 of WMO header)
(Octet 10 of PDB)

<u>Designator</u>	<u>Level</u>
97	Level of tropopause
96	Level of maximum wind

Otherwise the designator given is the hundred and tens digits of the pressure level e.g. 70 = 700 hPa (mb); 03 = 30 hPa (mb)

TABLE 5 GENERATING MODEL (Octet 6 of PDB)

From Table 2677, WMO Manual on codes, pub No. 306, vol. 1
See also WMO-No.9 vol. B.

<u>Designator</u>	<u>Model</u>
dec hex	
44 2C	Limited Area Model Forecast 19 level primitive equation model
45 2D	Global Model Forecast 19 level primitive equation model

TABLE 6 PARAMETER NUMBER (Octet 9 of PDB)

From Table 291, WMO Manual on codes, pub No. 306 vol. 1

<u>Code Figure</u>	<u>Field Parameter</u>	<u>Unit</u>
01	Pressure	hPa (mb)
02	Height	m
04	Temperature	degrees C
13	Relative Humidity	%
23	Eastward wind component	m/sec
24	Northward wind component	m/sec

APPENDIX B

GLOBAL PRODUCTS FROM THE GLOBAL MODEL (Areas a,b,c,d)

Wind	850 (HPa)	06	12	18	24	30	36
Wind	700 (HPa)	06	12	18	24	30	36
Wind	500 (HPa)	06	12	18	24	30	36
Wind	400 (HPa)	06	12	18	24	30	36
Wind	300 (HPa)	06	12	18	24	30	36
Wind	250 (HPa)	06	12	18	24	30	36
Wind	200 (HPa)	06	12	18	24	30	36
Wind	150 (HPa)	06	12	18	24	30	36
Wind	100 (HPa)	06	12	18	24	30	36
Temp	850 (HPa)	06	12	18	24	30	36
Temp	700 (HPa)	06	12	18	24	30	36
Temp	500 (HPa)	06	12	18	24	30	36
Temp	400 (HPa)	06	12	18	24	30	36
Temp	300 (HPa)	06	12	18	24	30	36
Temp	250 (HPa)	06	12	18	24	30	36
Temp	200 (HPa)	06	12	18	24	30	36
Temp	150 (HPa)	06	12	18	24	30	36
Temp	100 (HPa)	06	12	18	24	30	36
Trop. pressure		06	12	18	24	30	36
Trop. temp		06	12	18	24	30	36
Max. Wind Lev (HPa)		06	12	18	24	30	36
Max. Wind speed		06	12	18	24	30	36

APPENDIX C

EXAMPLE OF GRIB MESSAGES

In this example, the encoding is for a 12 hour forecast of the 500 HPa u-component of the wind on the C grid, from the initial reference time of 12z, July 15 1984. There will be 16 octets of communications header followed by:

WMO HEADER

<u>Octet No</u>	<u>Hex form</u>	<u>Description</u>
1	48	'H'
2	55	Type parameter ('U' = easterly wind component)
3	43	Grid identification ('C')
4	43	Time difference between reference time and the validity time of data ('C' = 12hrs)
5-6	3530	Level of data ('50' = 500 HPa)
7	20	Blank
8-11	45475252	Originating centre ('EGRR')
12	20	Blank
13-14	3135	Day of month ('15')
15-18	31323030	Hour and minute of reference time ('1200')
19-21	0D0D0A	Two carriage returns and a line feed

INDICATOR BLOCK

<u>Octet No</u>	<u>Hex form</u>	<u>Description</u>
1-4	47524942	'GRIB'

PRODUCT DEFINITION BLOCK

<u>Octet No.</u>	<u>Hex form</u>	<u>Description</u>
1-3	000018	Length of block (24 octets)
4	00	Reserved
5 4	A	Identification of centre (4A = Bracknell)
6	2D	Model ident. (2D = Global Forecast Model)
7	17	Grid ident. (23 = 'C')
8	00	Flag (0 = no optional blocks)
9	17	Parameter number (23 = u wind component)
10	64	Type of level (100 = isobaric)
11-12	01f4	Pressure of level (500 HPa)
13	54	Year of century (84)
14	07	Month of year (July)
15	0f	Day of month (15th)
16-17	0C00	Reference time of data (1200)
18	01	Forecast time unit (hours)
19	0C	Time range (T+12)
20-24	00000000	Reserved

GRID DESCRIPTION BLOCK

<u>Octet No.</u>	<u>Hex Form</u>	<u>Description</u>
1-3	20	Length of block
4		Number of unused bits at end of block 2
5	00	Set to zero (reserved)
6	00	Data representation type
7-8	49	Number of points along a latitude
9-10	49	Number of points along a longitude
11-13	15f90	Latitude of origin
14-16	000000	Longitude of origin
17	80	Resolution flag
18-21	000000	Latitude of extreme point
21-23	15f90	Longitude of extreme point
24-25	4E2	Longitude increment
26-27	4E2	Latitude increment
28	00	Scanning mode
29-32	00000000	Set to zero (reserved)

Note:

- 1) Latitude, longitude and increments are in milli degrees
- 2) Latitude values are in the range 0-90000. (sign bit + 24 bit integer)
- 3) Longitude values are in the range 0-360000 (sign bit + 24 bit integer)
- 4) Where values are not given the Octet has all bits set to 1

BITMAP BLOCK

<u>Octet No.</u>	<u>Hex form</u>	<u>Description</u>
1-3	0000AE	Length in Octets of BMB
4	0B	Number of unused bits at end of block
5-6	0000	Bit map follows
7-	E0.....	Bit map

BINARY DATA BLOCK

<u>Octet No.</u>	<u>Hex form</u>	<u>Description</u>
1-3	000540	Length in octets of BDB
4	00	Number of appended bits set to zero
5-6	8002	Scale factor (E=-2)
7-10	C213EF88	Reference value (R=-19.936)
11	08	Number of bits into which data is packed
12-nnn	4A.....	Binary data

END BLOCK (EB)

<u>Octet No.</u>	<u>Hex Form</u>	<u>Description</u>
1-4	37373737	End of message indicator (7777)

The End Block will be followed by the communication trailer 0D0D0A03 (hex)